

October 1986

ANL-PRISM-29

THERMAL-HYDRAULIC ANALYSIS OF RVACS TRANSIENT IN PRISM
USING COMMIX-1AR: QUASI-STEADY STATE RESULTS AFTER ONE DAY

by

P. L. Garner

Applied Physics Division
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

~~LIMITED DISTRIBUTION~~

~~The ANL-PRISM-TM series provides the documentation of results for the ANL~~
~~tasks performed~~
~~prepared print~~
~~preliminary and~~
~~referenced with~~

NO ACCESS RESTRICTIONS

This document is not considered OUO-Applied Technology. It was reviewed for Export Controlled Information and found to be suitable for unlimited access and reproduction.

This label reflects Applied Technology instructions issued April 13, 2006, by the the Department of Energy Office of Nuclear Energy. Additional guidance has also been provided by DOE in 2016 and 2018 memos, as well as from NNSA.

~~Any further~~
~~third parties~~
~~and foreign~~

Paul Betten

5/9/2019
Date

~~TM series is~~
~~ported are~~
~~quoted or~~

~~therein to~~
~~companies~~
~~to be coor-~~

~~ordinated with the Deputy Assistant Secretary for Breeder Reactor Programs, U. S.~~
~~Department of Energy.~~

TABLE OF CONTENTS

	<u>Page</u>
I. INTRODUCTION	1
II. MODEL DESCRIPTION AND BOUNDARY CONDITIONS	2
III. RESULTS	4
A. Without Overflow	4
B. With Overflow	7
IV. CONCLUSIONS	9
V. REFERENCES	10
APPENDIX A - Figures Showing Temperatures in Alternate Units	A-1

LIST OF FIGURES

	<u>Page</u>
1. Elevation View of COMMIX Model at Azimuthal Planes J=7 and 3	11
2. Plan View of COMMIX Model Just Below Pump Outlet Plenum (Axial Plane K=11)	12
3. Elevation View of Velocity Distribution Calculated by COMMIX for QSS at 1 Day Without Overflow	13
4. Velocity Distribution Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day Without Overflow	14
5. Velocity Distribution Calculated by COMMIX in RV/GV Gap for QSS at 1 Day Without Overflow	15
6. Elevation View of Temperature Distribution [°C] Calculated by COMMIX for QSS at 1 Day Without Overflow	16
7. Temperature Distribution [°C] Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day Without Overflow	17
8. Temperature Distribution [°C] Calculated by COMMIX in RV/GV Gap for QSS at 1 Day Without Overflow	18
9. Temperature Distribution [°C] Calculated by COMMIX in GV/CC Gap for QSS at 1 Day Without Overflow	19
10. Representative Radial Temperature Distribution [°C] Calculated by COMMIX at Top of Hot Pool for QSS at 1 Day Without Overflow	20
11. Elevation View of Velocity Distribution Calculated by COMMIX for QSS at 1 Day With Overflow	21
12. Velocity Distribution Calculated by COMMIX in RV/GV Gap for QSS at 1 Day With Overflow	22
13. Elevation View of Temperature Distribution [°C] Calculated by COMMIX for QSS at 1 Day With Overflow	23
14. Temperature Distribution [°C] Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day With Overflow	24
15. Temperature Distribution [°C] Calculated by COMMIX in RV/GV Gap for QSS at 1 Day With Overflow	25
16. Temperature Distribution [°C] Calculated by COMMIX in GV/CC Gap for QSS at 1 Day With Overflow	26

LIST OF FIGURES (Cont'd)

	<u>Page</u>
17. Representative Radial Temperature Distribution [$^{\circ}\text{C}$] Calculated by COMMIX at Top of Hot Pool for QSS at 1 Day With Overflow	27
A-6. Elevation View of Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX for QSS at 1 Day Without Overflow	A-2
A-7. Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day Without Overflow	A-3
A-8. Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX in RV/GV Gap for QSS at 1 Day Without Overflow	A-4
A-9. Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX in GV/CC Gap for QSS at 1 Day Without Overflow	A-5
A-10. Representative Radial Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX at Top of Hot Pool for QSS at 1 Day Without Overflow	A-6
A-13. Elevation View of Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX for QSS at 1 Day With Overflow	A-7
A-14. Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day With Overflow	A-8
A-15. Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX in RV/GV Gap for QSS at 1 Day With Overflow	A-9
A-16. Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX in GV/CC Gap for QSS at 1 Day With Overflow	A-10
A-17. Representative Radial Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX at Top of Hot Pool for QSS at 1 Day With Overflow	A-11

THERMAL-HYDRAULIC ANALYSIS OF RVACS TRANSIENT IN PRISM
USING COMMIX-1AR: QUASI-STEADY STATE RESULTS AFTER ONE DAY

by

P. L. Garner

ABSTRACT

The PRISM reactor has been analyzed at conditions corresponding to 1 day following initiation of an RVACS transient, in which all pumping power is lost and the post-scrum decay power (0.58% of nominal) is being removed from the reactor vessel solely by natural circulation of air through the reactor vessel auxiliary cooling system. The IFR-variant of the COMMIX-1AR computer code was used to calculate the three-dimensional fluid flow and temperature fields within the primary system and its immediate surroundings. Relative to full-power/full-flow conditions, the sodium is found to circulate through the primary system in a natural convection mode at a flow rate of 1.5-1.9% and the temperatures are found to be 150-270°C (270-490°F) hotter. If sodium from the hot pool is allowed to return to the cold pool via an overflow path, then this results in a decreased flow through the normal return path via the intermediate heat exchanger. Inclusion of the overflow path had little apparent long term effect on the efficiency of heat removal via the reactor vessel auxiliary cooling system or on primary sodium temperatures. Appreciable differences could exist for transients during which the intermediate heat exchanger interacts with active intermediate and secondary systems; this needs to be investigated further.

I. INTRODUCTION

An important safety feature of the Power Reactor Inherently Safe Module (PRISM) design (Ref. 1) is provision for a path through which atmospheric air flows by natural convection over the outside surface of the primary system at all times. The flow path in this reactor vessel auxiliary cooling system (RVACS) is sized to insure system integrity by removing post-scam decay heat generation in a totally passive manner in the event that all active heat removal components are rendered unavailable during a transient. Under these conditions, the sodium flow within the primary system would undergo a transition from forced to natural circulation mode, the latter being driven by thermal gradients in the system. A proper analysis of these off-normal transients requires a coupled solution of the fluid flow and heat transfer equations in three spatial dimensions and in time. This analysis capability is provided by the COMMIX computer code, a version of which is used in the present analysis.

The present work examines one portion of an "RVACS transient", which was initiated by a loss of power to all primary and intermediate system coolant pumps and accompanied by a reactor scram. A steady-state calculation has been performed using as boundary conditions those expected at one specific time in the transient; this calculational approach is denoted quasi-steady state (QSS). The specific time selected is 1 day after initiation; preliminary lumped-parameter analyses¹ indicate that this is the approximate time at which the power removed by the RVACS will exceed the power generated in the core. This corresponds to the beginning of the long-term (1-2 months) cooldown phase of the transient and system temperatures should be at their maximum values. The QSS approach should provide a reasonably good estimate of the fluid flow and temperature fields, since the lumped-parameter analyses predict that changes are occurring slowly at this point in the transient. This approach is not a substitute for performing the full transient calculation in three dimensions but is an expedient way of scoping the long-term coolability of the system and provides a reference against which the transient calculation may be compared when performed.

The remainder of this report presents the way in which the COMMIX code was used to calculate the conditions expected 1 day after initiation of the

RVACS transient. The effect of preventing versus allowing sodium from the hot pool to return to the cold pool via an overflow path is considered. This work is a continuation of the full-power/full-flow steady-state analysis presented in Ref. 2 and forms the second part of a comprehensive thermal-hydraulics analysis program for PRISM. This report supersedes the analysis presented in Ref. 3 and incorporates revisions to the reactor design, the structure of the COMMIX model, and the transient conditions.

II. MODEL DESCRIPTION AND BOUNDARY CONDITIONS

The present calculations were performed using the IFR-variant of the COMMIX-1AR computer code (Ref. 4). In addition to the normal porous medium formulation of the mass, momentum, and energy conservation equations in three dimensions found in all COMMIX code versions, the IFR-variant allows for multiple fluids to be considered in physically separated regions of the calculational domain and allows for radiative heat transfer between surfaces of thermal structures. The specific version of the code contained a preliminary formulation of the radiative heat transfer model, which was less rigorous than in the version used for the steady-state calculations reported in Ref. 2; although this should not be a significant factor in the results, the difference is noted for completeness.

The calculation used the same 90° sector representation of the primary system and surroundings as was used for the steady-state calculations reported in Ref. 2. The major features of the geometry are illustrated in Figs. 1 and 2. The normal sodium flow pattern is up through the pump duct (cells (I-radial, J-azimuthal, K-axial)=(6,3,8-11)) to the pump outlet plenum (cells (5-7,1-5,12-13)); down through two pipes (azimuthal cells J=11 and J=5) to the core inlet plenum (cells (1-4,1-8,2-3)); up through the assemblies (cells (1-4, 1-8, 4-7)) and the upper internals structure (UIS) region (cells (1-4,1-8,8-19)) to the upper portion of the hot pool (cells (1-7,1-8,17-19)); down through the intermediate heat exchanger (IHX) (cells (5-7,6-8,9-16)) to the cold pool; and up through the fixed shield region (cells (5-6,1-8,4-6)) to the pump inlet plenum (cells (5-7,1-5,7)). The annular gap between the reactor vessel (RV) and the guard vessel (GV) (cells

(10-11,1-8,1-19)) contains Argon gas. The annular space between the GV and the collector cylinder (CC) cells (12-13,1-8,1-19)) is the air riser portion of the RVACS. The specifics of the geometry, along with the heat transfer and frictional resistance model parameters, are detailed in Ref. 2 and will not be repeated here.

The time into the RVACS transient was taken as approximately 1 day. This point is far enough into the transient that there is no head being supplied by the primary pumps; the mode of sodium flow within the RV is natural convection as induced by thermal gradients. There is also no flow of sodium in the intermediate loop and thus no heat rejection from the primary sodium through the IHX. The power generation is all due to fission product decay in the fuel; this generation rate¹ is 2.5 MW* (8.5×10^6 Btu/hr), which corresponds to 0.58% of full power conditions. This heat source was located in the core fuel (cells (1-2,1-8,5)); although additional fuel was physically present in the storage rack in the model (cells (4,1-8,8-13)), its power generation was assumed to be negligible compared with that in the core. The only means of removing heat from the RV is provided by the RVACS. Even though the air mass flow through the RVACS is in a natural convection mode, the flow rate at the bottom of the riser must be specified as input to the COMMIX code, since only a portion of the RVACS is modeled. This flow rate is a function of the average RV temperature, which, in turn, is a function of the average RV surface heat flux. Since all heat generated in the fuel must pass through the RV under the QSS assumption, the RV surface heat flux is known; using the tabulation in Ref. 5, the air mass flow rate is, thus, found to be 26.6 kg/s (59 lbm/s). All other boundary conditions are the same as used for the full-power/full-flow calculation reported in Ref. 2.

The PRISM design provides an alternate path for sodium in the hot pool to return to the cold pool under some transient conditions. The actuation of this alternate path is passive: if the sodium expands sufficiently during heatup, the hot pool level rises to slots cut through the upper

*All "extensive" numbers in this report are stated for the entire reactor module, not just the 90° sector modeled.

portion of the reactor vessel liner (RVL), allowing this sodium to enter the top of the annular space between the RVL and the RV, and flow downward through this gap to the cold pool. The sodium exchanges energy with RV while flowing through this gap, supplementing (or replacing) the energy removal capability normally provided by the IHXs. The COMMIX code is not able to model a free surface level and, thus, can not be used to predict the onset of overflow; therefore, separate calculations were performed which excluded and included this overflow. In both cases, the RVL/RV gap was assumed to be completely filled with sodium in the model. (The actual design conditions are such that the hot pool level is 0.46 m (1.5 ft) below the slots and the sodium level in the RVL/RV gap is 3.8 m (12.5 ft) below the slots during normal operation; the difference between these two free surface levels is a function of the pressure drops around the system.) The difference between the two cases was whether or not sodium was allowed to flow from the hot pool into the top of the RVL/RV gap. This was allowed by setting the surface permeability of the RVL (located between radial nodes I=7 and I=8) to a value of 0.2 at axial node K=19; this permeability was zero when overflow was excluded.

III. RESULTS

A. Without Overflow

The overall nature of the primary sodium flow field is shown in Fig. 3. The general character of this flow is the same as found for steady state (Fig. 5 of Ref. 2). The sodium velocity magnitudes are, however, smaller in the present QSS calculation than they were at normal steady state. The primary system flow is 34 kg/s (0.27×10^6 lbm/hr) and is totally due to the thermal gradients in the system. This flow is 1.5% of the steady-state value; since the power is at 0.58%, the power-to-flow ratio is 0.39. Upward flow is maintained in all core assemblies. The flow pattern in the UIS region differs from that calculated at full-power/full-flow conditions. The present calculation shows a thermally induced circulation pattern in the annular space (radial node I=4) between the UIS baffle plates and the fuel

storage rack: flow is upward on the hot IHX side (azimuthal nodes $J = 6-8$) and downward on the cold pump side ($J = 1-5$). In contrast, all flow in this annular region was upward under the forced circulation conditions reported in Ref. 2. Similarly, circulatory flow exists in the annular gap between the fixed shielding and the RV.

The velocity distribution in the RVL/RV gap is shown in Fig. 4; the left half of this figure is for $I=8$ (adjacent to the RVL), the right half is for $I=9$ (adjacent to the RV), the center corresponds to $J=1$ (pump side), and the left and right edges both correspond to $J=8$ (IHX side). This flow is generally similar to that calculated at steady state (Fig. 9 of Ref. 2). The lower portion shows a circulation pattern which is upward along the middle of the IHX and downward on the pump side; there is also downward flow at $J=8$ along the IHX which was not noted at steady state. The upper portion (axial nodes $K = 17-19$) of this field shows upflow along the RVL and downflow along the cooler RV surface.

The velocity field calculated for the Argon gas located in the RV/GV gap is shown in Fig. 5. The majority of this field shows a circulation similar to that seen in the lower portion of the RVL/RV gap. The details of this convection pattern are relatively insignificant, since 98% of the energy transfer from the RV to the GV is by thermal radiation rather than convection.

The overall character of the temperature field is shown in Fig. 6*. The sodium undergoes little temperature change between the pump and the core inlet plenum, entering the assemblies at 587°C (1089°F). The temperature peaks at 644°C (1191°F) at the top of the fuel in the driver assemblies (cells (1,1-8,5)). The temperature rise across the core is lower than found for normal steady state due, primarily, to the lower power-to-flow ratio. The temperatures in the assemblies are also affected by conduction of heat radially through the assembly walls and the fixed shields; this effect was not as noticeable at steady state where axial convection dominates the energy transport at full flow. As was the case at steady state, the

*A duplicate set of figures showing temperatures in [$^{\circ}\text{F}$] is included as Appendix A.

temperature becomes fairly uniform in the UIS and maintains that uniformity in the upper part of the hot pool. Sodium enters the top of the IHX at 626°C (1159°F). The temperature decreases by 6°C (11°F) while flowing downward through the IHX; the energy given up is transferred through the tube walls, stagnant intermediate sodium, IHX casing, interstitial sodium, and the RVL to the sodium in the RVL/RV gap. In contrast to the steady state result, the cold pool is not uniform in this QSS calculation; the temperature variation is primarily in the axial direction. The fluid in the cold pool is transferring energy radially to the fixed shield and to the RV, decreasing in temperature by 41°C (74°F) during its travel from the bottom of the IHX to the bottom of the fixed shields. About 9°C (16°F) of this decrease is recovered during flow upward through the fixed shields to the pump inlet. The lowest sodium temperature is in the relatively isolated region of the cold pool at K=1, which is below the core inlet plenum; the temperature in this region is 576°C (1069°F). The global sodium temperatures in the QSS calculation are determined by the air temperature and energy removal mechanisms in the RVACS, which is having to remove all of the power generated in the core. On a global basis, the primary sodium is 150-270°C (270-490°F) hotter than steady state in this QSS calculation, as may be seen by comparing this figure with Fig. 10 of Ref. 2.

The temperature of the sodium in the RVL/RV gap is shown in Fig. 7. The temperature variation is primarily in the axial direction but with a small azimuthal component; the temperature variation in the radial direction is negligible. This temperature distribution is consistent with the velocity distribution shown in Fig. 4.

The temperature distribution in the Argon between the RV and GV is shown in Fig. 8. Overall there is little azimuthal variation and a small radial variation; the primary variation is in the axial direction. The temperature distribution in the air between the GV and the CC is shown in Fig. 9. As was the case in steady state, the primary temperature variation is axial in this upward flowing field; there is a minor radial variation and negligible azimuthal variation. The average exit temperature of the air is 125°C (257°F). The power being removed by the RVACS is 2.4 MW (8.3×10^6 Btu/hr), which is in reasonable agreement with (but 2% less than) the core power generation. The air removes 56% of the power by convective cooling at

the outer surface of the GV; the other 44% of the power leaving the GV is radiated to the inner surface of the CC, where it is then transferred to the air by convection. Figure 10 shows a typical radial temperature distribution, from the hot pool through the air, at the top of the model; the temperature change across this region is 509°C (916°F), which is 30% bigger than at steady state (cf. Fig. 16 of Ref. 2); the majority (67%) of this radial temperature change in the current calculation occurs between the GV and the air, which is a noticeable increase from the 45% share attributable to this gap at steady state.

B. With Overflow

A QSS calculation was also performed for the situation in which sodium from the hot pool was allowed to overflow through the slots in the top of the RVL into the gap between the RVL and the RV. This was accomplished by setting the surface permeability of the RVL to 20% (rather than zero) at axial level K=19; the rest of the input to COMMIX was identical to that used for the case without overflow.

The overall characteristics of the primary sodium velocity distribution are shown in Fig. 11. As was found in the case without overflow, the sodium flow is up through the pump duct, down through the piping to the core inlet plenum, and upward through all assemblies, with a circulation pattern evident in the UIS region. The primary path for return of the sodium in the hot pool to the cold pool is via the RVL/RV gap, rather than through the IHX. The 38 mm (1.5 in) space between the RVL and the RV presents less resistance to the flow than is presented by 4000 tubes in the IHXs with an inside diameter of 17 mm (0.67 in). The total sodium mass flow rate through the core is 43 kg/s (0.34×10^6 lbm/hr); this is 27% larger than the flow rate calculated under QSS conditions without overflow (reflecting the decreased resistance of the return path) and is 1.9% of the steady-state value (resulting in a power-to-flow ratio of 0.31). The net mass flow through the IHX is actually upward in this case, at a rate of 0.8 kg/s (2 lbm/s) which is essentially negligible since it corresponds to only 2% of the core flow. Below the bottom of the RVL/RV gap, the flow is essentially the same as found in the case without overflow.

The velocity distribution in the Argon region is shown in Fig. 12. The entire height of this field is in the same double circulation pattern found in the upper portion of this region for the calculation without overflow. The velocities are much smaller than in the previous case and relatively insignificant; 99% of the heat transfer from the RV to the GV is by thermal radiation.

The overall character of the temperature distribution is shown in Fig. 13. As was found in the case without overflow, the temperature undergoes little change between the pump and the core inlet, entering the assemblies at a temperature of 592°C (1097°F). The temperature peaks at 638°C (1180°F) at the top of the fuel in the driver assemblies. The temperature rise across the core is consistent with the power-to-flow ratio after accounting for radial conduction through the assembly walls and fixed shielding, which is significant as was found in the case without overflow. The temperature is fairly uniform in the UIS region and the upper hot pool. The flow from this pool enters the top of RVL/RV gap at a temperature of 631°C (1168°F) and exits the bottom of the gap at a temperature of 604°C (1119°F) as shown in Fig. 14; the sodium in this gap is losing energy through the RVL to the primary sodium in the pump and IHX regions and through the RV to the Argon. As in the case without overflow, the cold pool is not uniform in temperature; the sodium exiting the bottom of the RVL/RV gap decreased by 20°C (36°F) before reaching the bottom of the fixed shields. About half of this temperature loss is recovered during the flow upward through the fixed shields to the pump inlet plenum. The lowest sodium temperature is 580°C (1076°F) and located at the bottom of the RV. Overall, the sodium temperatures in this case are somewhat hotter than in the case without overflow but this difference (5°C or 9°F) does not seem to be significant.

The temperature distribution in the Argon space between the RV and the GV is shown in Fig. 15; the distribution is similar to that found for the case without overflow, only somewhat smoother and showing somewhat higher temperatures. The temperature distribution in the air is shown in Fig. 16; the distribution has characteristics similar to that found for the case without overflow. The average exit temperature of the air is 128°C (262°F), which is 3°C (5°F) higher than for the case without overflow. The power

being removed by the RVACS is 2.5 MW (8.5×10^6 Btu/hr) which balances the power being generated in the core (actually exceeding it by 1%). The heat transfer at the outer surface of the GV has the same split between convective (56%) and radiative (44%) components as found in the case without overflow. Figure 17 shows a typical radial temperature distribution, from the hot pool through the air, at the top of the hot pool; the overall radial temperature change between the hot pool and the air is the same as calculated for the case without overflow; however, allowing flow of sodium from the hot pool to the RVL/RV gap leads to slightly higher temperatures (3-21°C or 5-38°F) in this region.

IV. CONCLUSIONS

The present calculations have shown the three-dimensional fluid flow and temperature fields expected in the PRISM system during an RVACS transient about 1 day after initiation. Sodium circulates through the primary system in a natural convection mode, as driven by thermal gradients. The heat generated in the fuel, which is all from fission product decay, is all ultimately removed from the RV by the passive operation of the RVACS. Although the power-to-flow ratio in the core is low (0.3 to 0.4), the temperature of the primary sodium is 150-270°C (270-490°F) hotter than calculated at full-power/full-flow conditions; the hotter primary sodium temperatures are directly related to the air temperature and energy removal mechanisms in the RVACS. Even with this temperature increase, the primary sodium is still more than 250°C (450°C) below its boiling point. Although the temperature distribution within the hot pool retains its uniformity, thermal gradients are present in the cold pool.

The calculations with COMMIX indicate that allowing for overflow of hot pool sodium into the gap between the RVL and the RV has little apparent impact on the long-term heat removal capability when calculated on a quasi-steady-state basis. The overflow of hot sodium into the RVL/RV gap increases the average RV temperature by 11°C (20°F) which slightly enhances heat removal from the primary system via the RVACS. The most noticeable effect of allowing overflow into the RVL/RV gap is its potential for leading

to flow stagnation (or reversal) on the primary side of the IHX; again, this had little significance in the present calculation. The effects of the overflow path, however, may be important for other transients in which the intermediate loop is intended to provide some level of (flow and) heat removal capability and need to be investigated further.

V. REFERENCES

1. "PRISM: Reactor System (SDD-31)," Spec. No. 23A3110, General Electric Corp., Rev. A (September 1985).
2. P. L. Garner, "Three-Dimensional Thermal-Hydraulic Analysis of PRISM at Steady State Using COMMIX-1AR," ANL-PRISM-28, Argonne National Laboratory (August 1986).
3. F. F. Chen, P. L. Garner, and D. J. Malloy, "Preliminary Design COMMIX-1A Three-Dimensional Analysis," ANL-PRISM-6, Argonne National Laboratory (January 1986).
4. F. F. Chen, H. N. Chi, W. T. Sha, and V. L. Shah, "Development of a Thermal Radiation Model for the COMMIX-1A Computer Code," ANL-85-48, Argonne National Laboratory (September 1985).
5. J. H. Tessier, unpublished data (January 20, 1986).

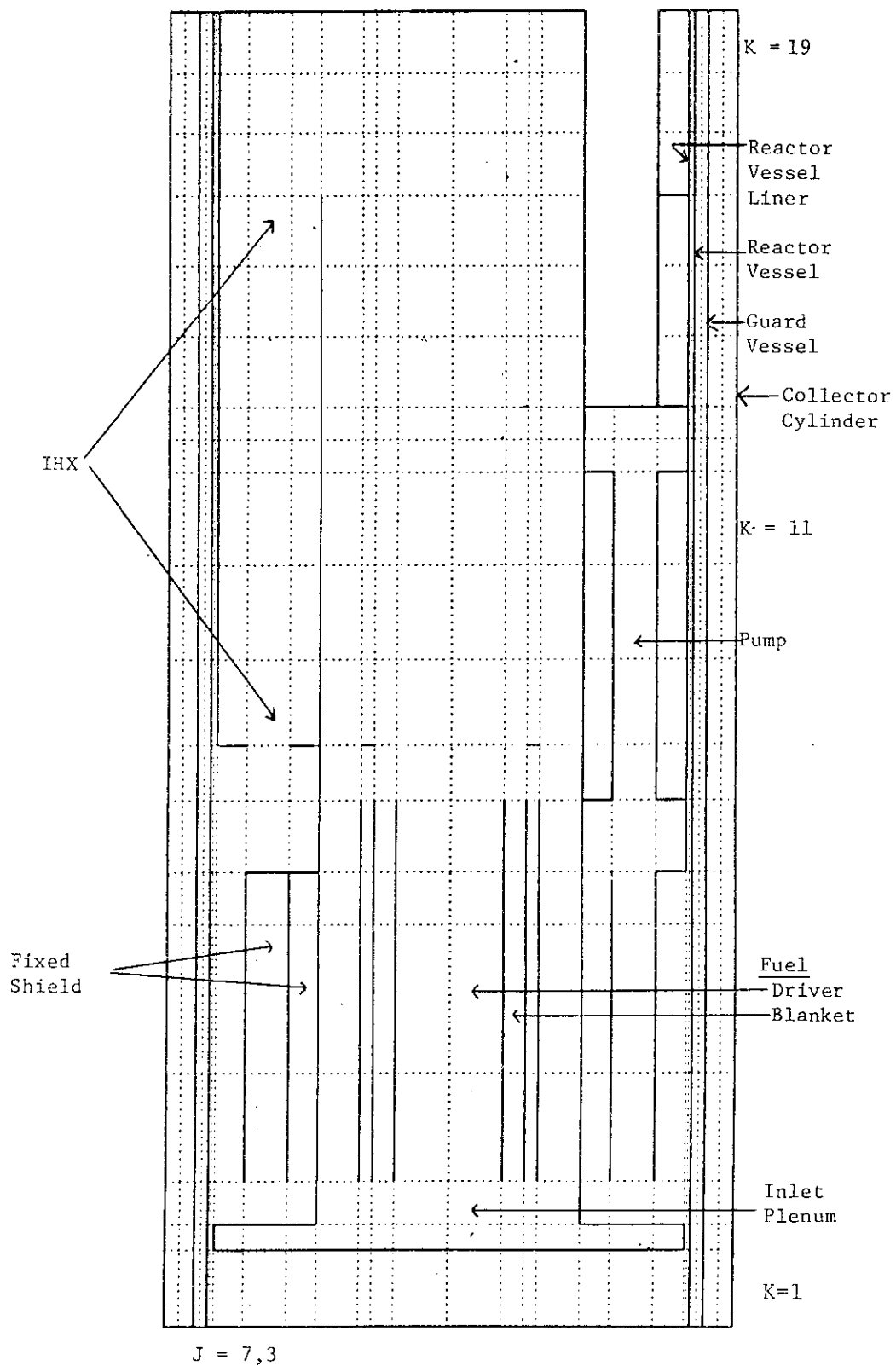


Fig. 1. Elevation View of COMMIX Model at Azimuthal Planes J=7 and 3

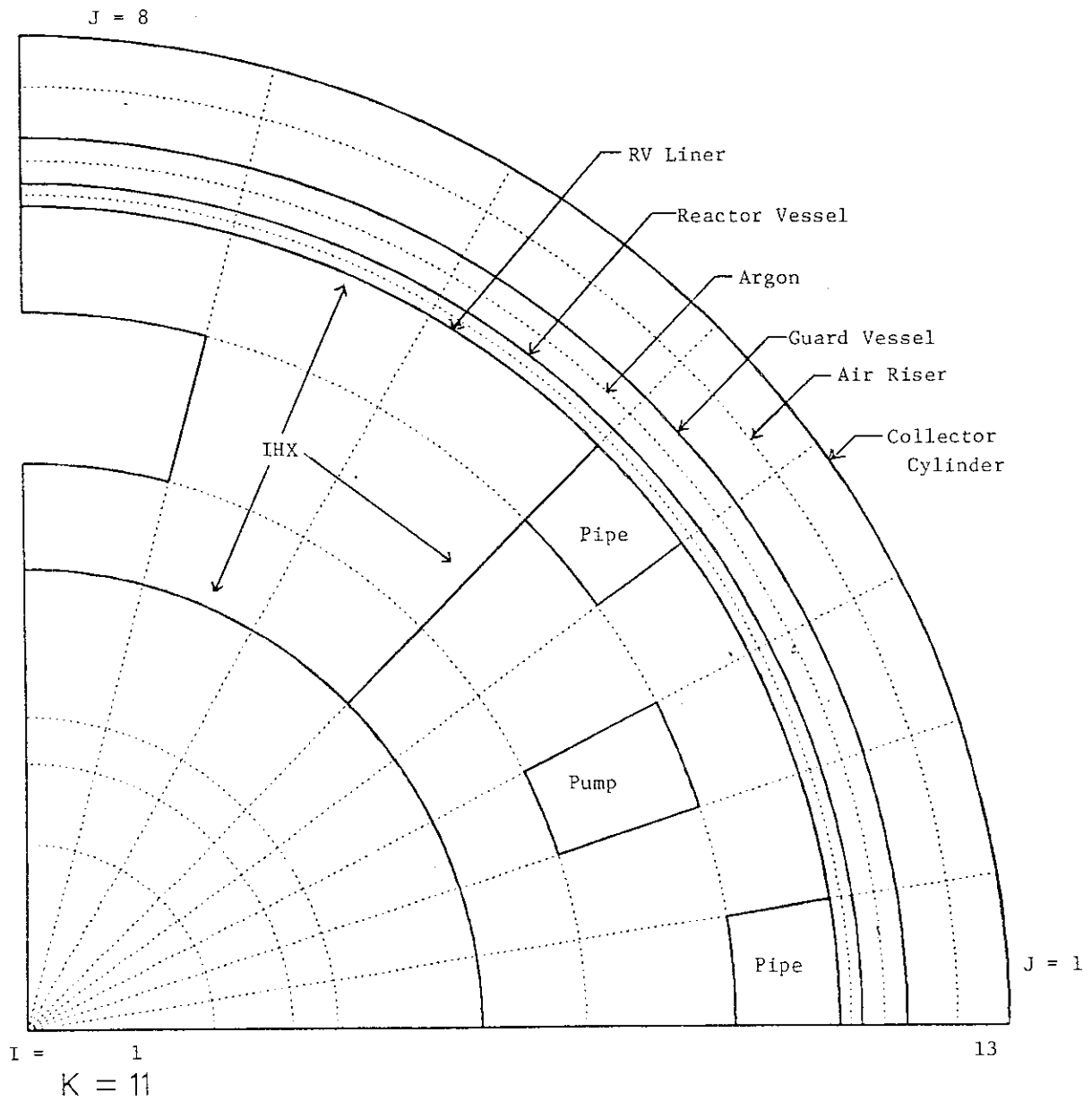
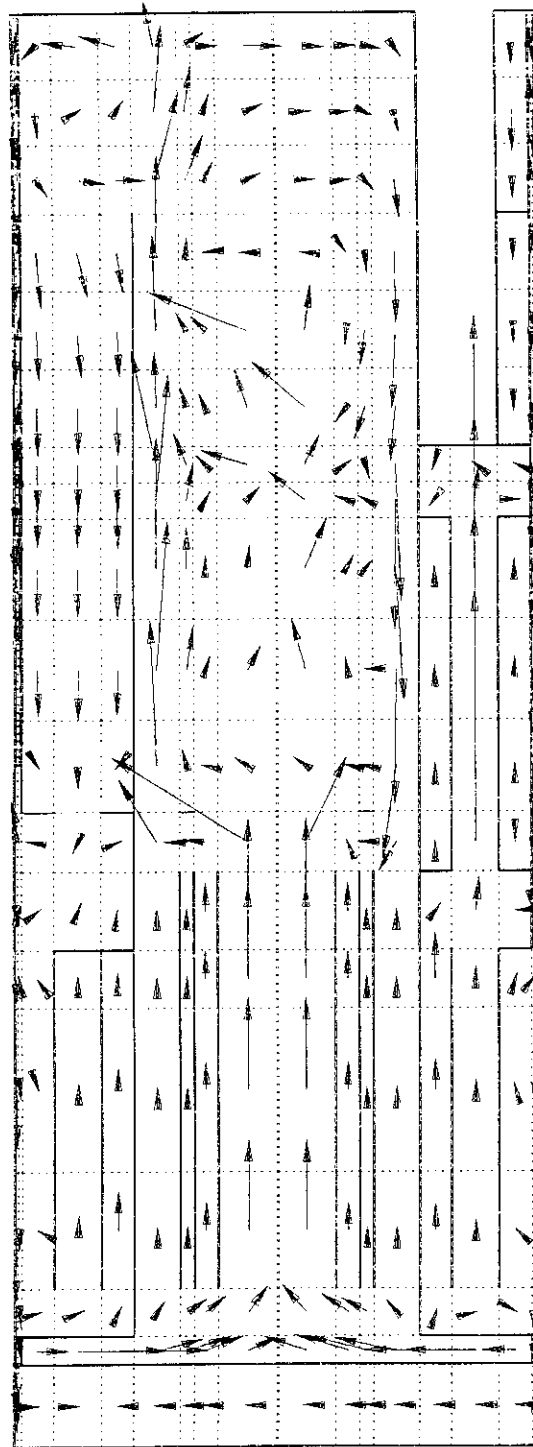


Fig. 2. Plan View of COMMIX Model Just Below Pump Outlet Plenum (Axial Plane K=11)



$J = 7, 3$
→ 0.15 M/S (6 in/s)

Fig. 3. Elevation View of Velocity Distribution Calculated by COMMIX for QSS at 1 Day Without Overflow

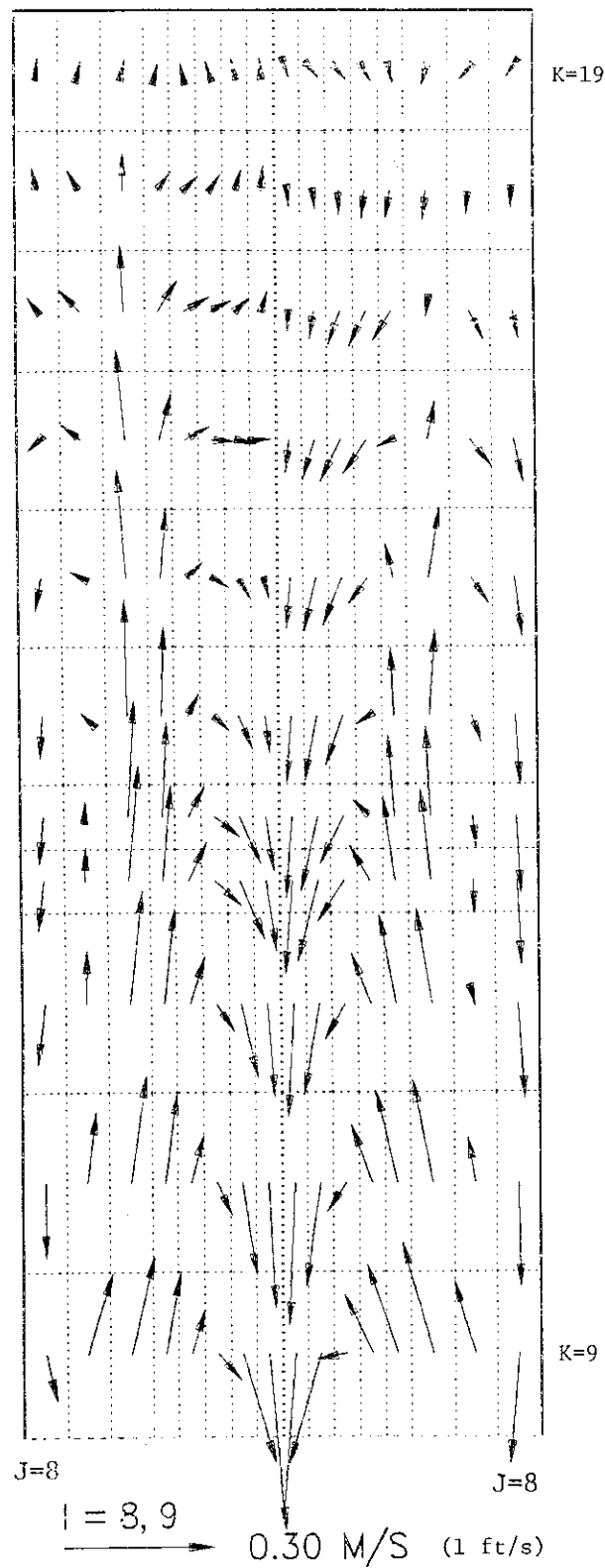


Fig. 4. Velocity Distribution Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day Without Overflow

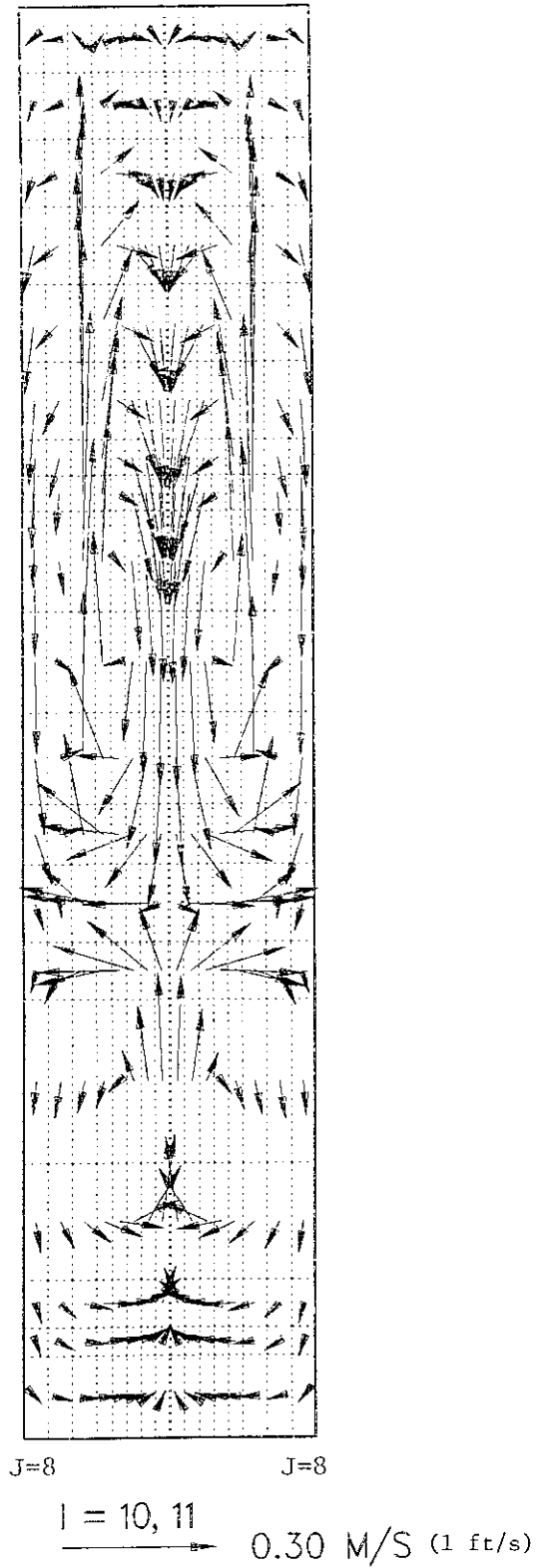
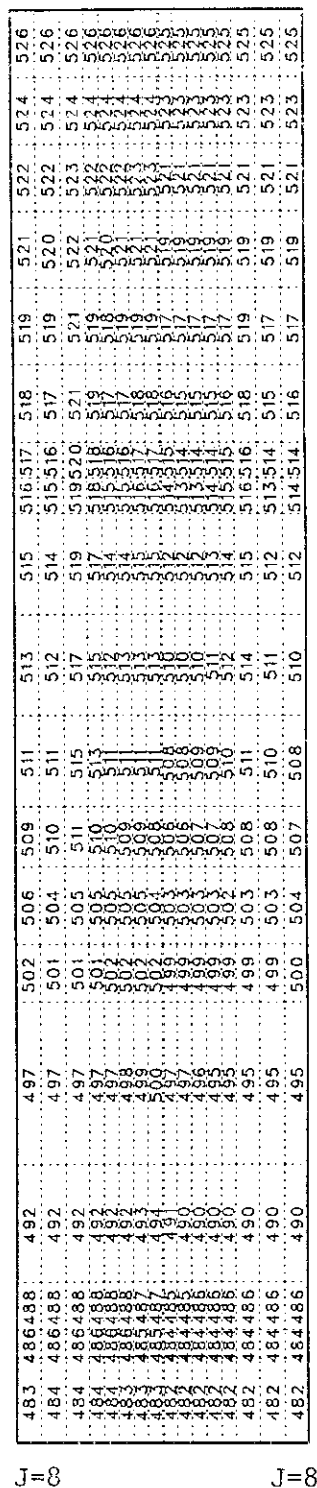


Fig. 5. Velocity Distribution Calculated by COMMIX in RV/GV Gap for QSS at 1 Day Without Overflow

J=8										J=8										K=19											
598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598
606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606	606
608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608	608
604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604
601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601
598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598
596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596	596
595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595
593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593
594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594
598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598	598
601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601
604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604	604
607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607	607
603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603	603
595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595	595
K=9										K=9										K=19											

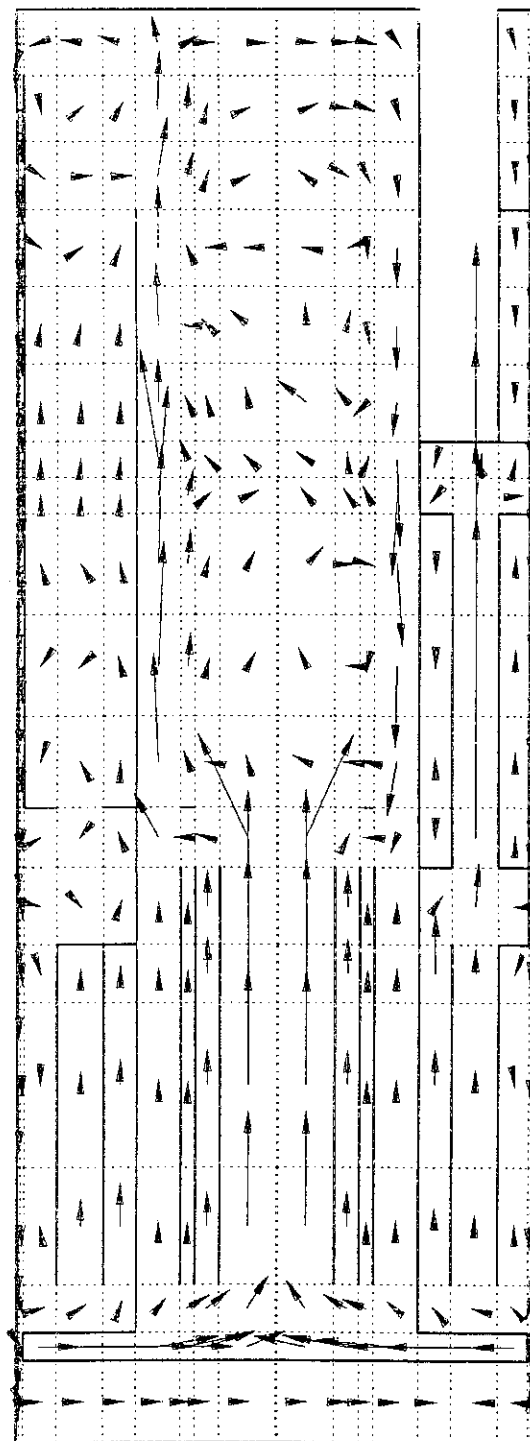
I = 8, 9

Fig. 7. Temperature Distribution [$^{\circ}\text{C}$] Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day Without Overflow



I = 10, 11

Fig. 8. Temperature Distribution [°C] Calculated by COMMIX in RV/GV Gap for QSS at 1 Day Without Overflow



$J = 7, 3$
→ 0.15 M/S (6 in/s)

Fig. 11. Elevation View of Velocity Distribution Calculated by COMMIX for QSS at 1 Day With Overflow

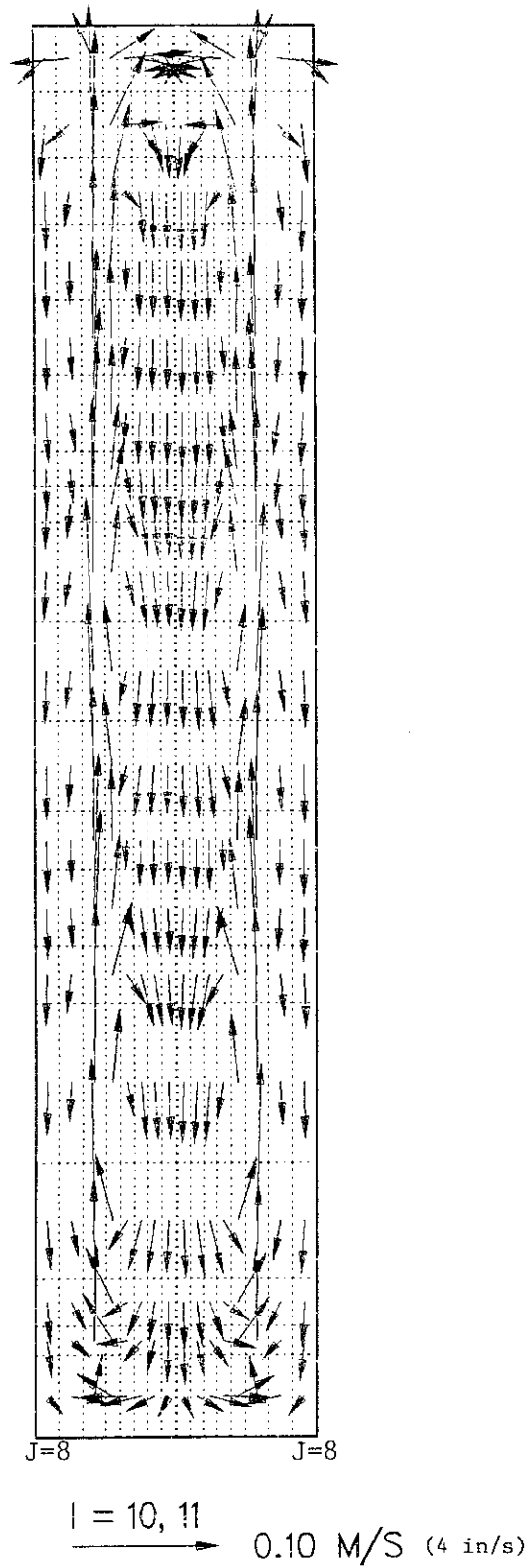
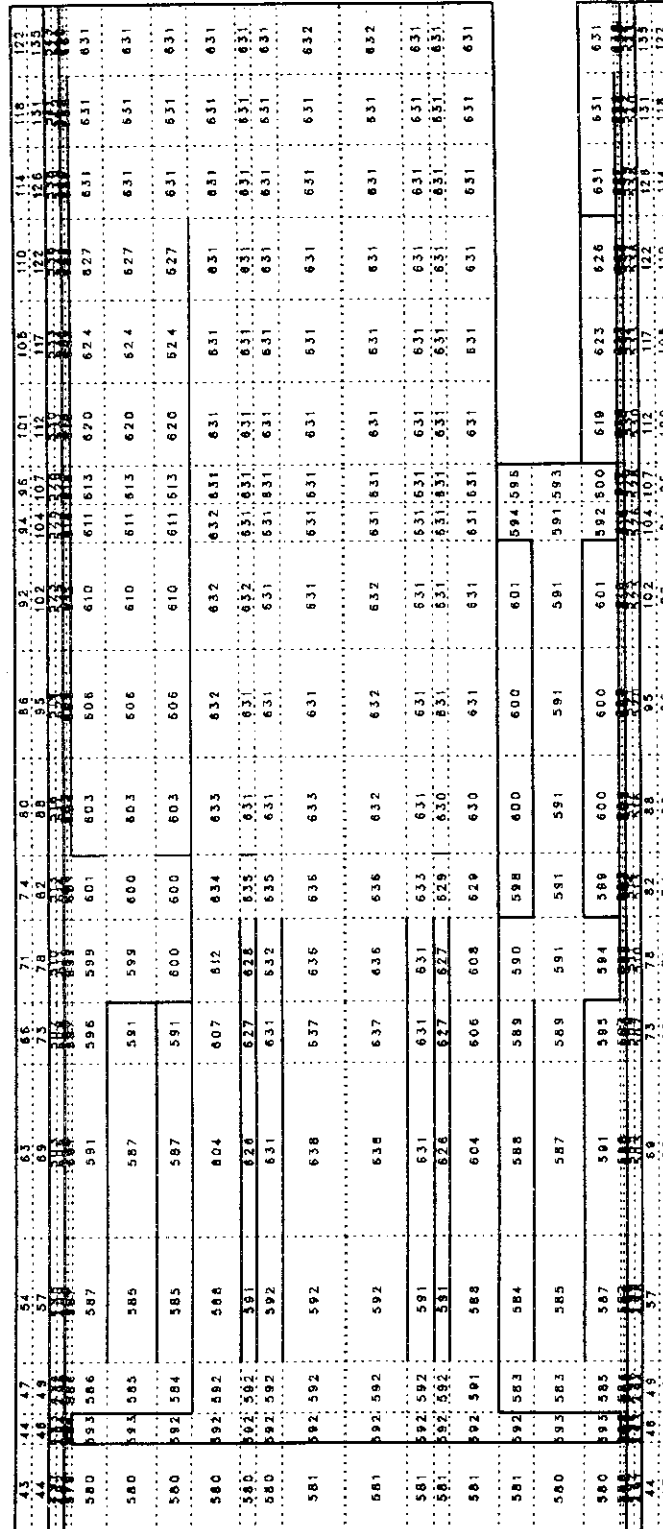


Fig. 12. Velocity Distribution Calculated by COMMIX in RV/GV Gap for QSS at 1 Day With Overflow



J=8												J=8											
604	608	612	616	618	620	622	625	627	629	630	603	606	610	614	616	618	620	622	625	627	629	630	
604	608	612	616	618	619	622	625	627	629	631	603	606	610	614	615	616	618	620	623	625	627	629	631
604	608	612	616	618	619	622	625	627	629	631	603	606	610	614	615	616	618	620	623	625	627	629	631
604	607	611	614	617	619	622	625	627	629	631	603	606	610	614	615	616	618	620	623	625	627	629	631
605	607	610	614	617	620	623	625	627	629	630	603	606	610	614	615	616	618	620	623	625	627	629	630
604	607	610	614	617	620	623	625	627	629	631	603	606	610	614	615	616	618	620	623	625	627	629	630
604	607	610	614	617	620	622	625	627	629	631	603	606	610	614	615	616	618	620	623	625	627	629	631
605	607	610	614	617	620	622	625	627	629	631	603	606	610	614	615	616	618	620	623	625	627	629	631
603	606	610	615	616	618	620	623	625	627	629	603	606	610	615	616	618	620	623	625	627	629	630	631
603	606	610	615	617	618	621	623	625	627	628	603	606	610	615	616	618	620	623	625	627	629	630	631
603	606	610	615	617	618	621	623	625	626	628	603	606	610	615	616	618	620	623	625	627	629	630	631
603	606	610	615	616	618	621	623	625	627	628	603	606	610	615	616	618	620	623	625	627	629	630	631
603	606	610	614	616	618	620	623	625	627	629	603	606	610	614	616	618	620	623	625	627	629	630	631
603	606	611	615	616	618	620	623	625	627	629	603	606	611	615	616	618	620	623	625	627	629	630	631
603	607	611	615	616	618	620	623	625	627	629	603	607	611	615	616	618	620	623	625	627	629	630	631
603	607	611	615	617	618	620	623	625	626	628	603	607	611	615	617	618	620	623	625	626	628	629	630

I = 8, 9

K=9

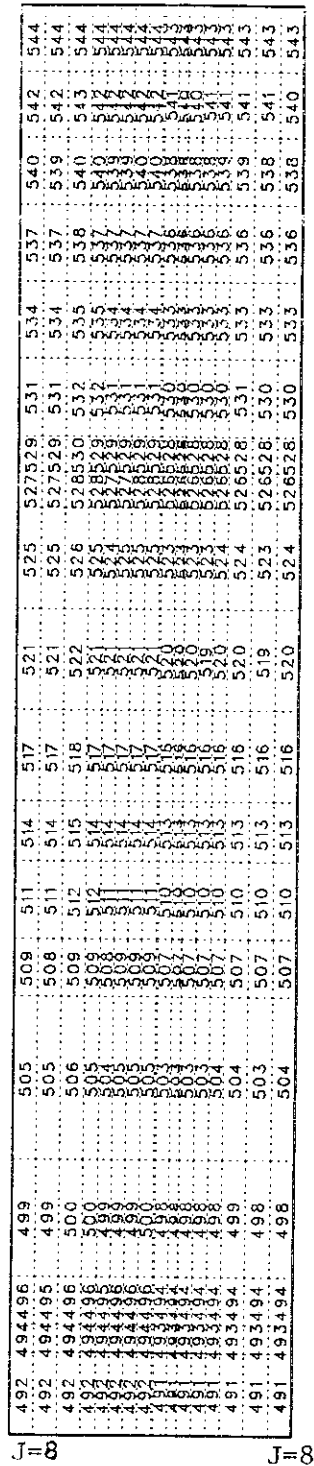
K=19

K=19

K=9

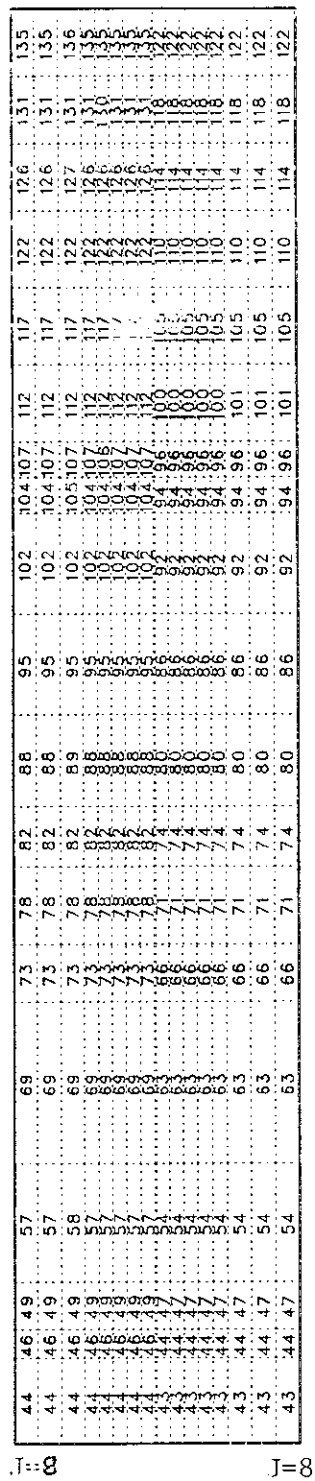
I = 8, 9

Fig. 14. Temperature Distribution [°C] Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day With Overflow



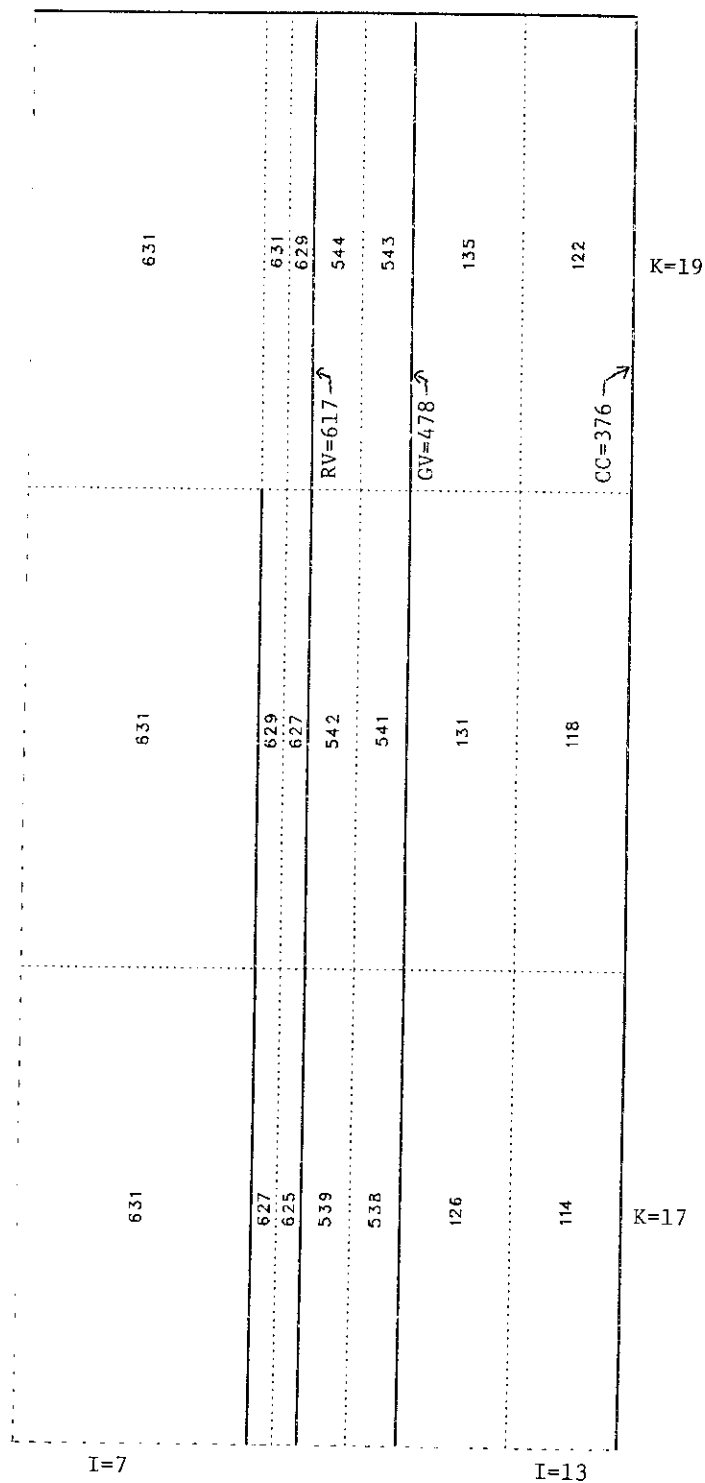
I = 10, 11

Fig. 15. Temperature Distribution [$^{\circ}\text{C}$] Calculated by COMMIX in RV/GV Gap for QSS at 1 Day With Overflow



I = 12, 13

Fig. 16. Temperature Distribution [$^{\circ}\text{C}$] Calculated by COMMIX in GV/CC Gap for QSS at 1 Day With Overflow



J = 7

Fig. 17. Representative Radial Temperature Distribution [$^{\circ}\text{C}$] Calculated by COMMIX at Top of Hot Pool for QSS at 1 Day With Overflow

APPENDIX A: Figures Showing Temperatures in Alternate Units

In the main body of the text, figures showing temperatures were prepared using units of degrees Celsius. As an aid to comparing these results with others, an alternate set of figures using units of degrees Fahrenheit has been prepared and included as this appendix. The figure numbering follows that of the main text; for example, Fig. A-6 of this appendix is the presentation in [$^{\circ}\text{F}$] of the information previously shown in [$^{\circ}\text{C}$] as Fig. 6 in the main text.

1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490	1491	1492	1493	1494	1495	1496	1497	1498	1499	1500	1501	1502	1503	1504	1505	1506	1507	1508	1509	1510	1511	1512	1513	1514	1515	1516	1517	1518	1519	1520	1521	1522	1523	1524	1525	1526	1527	1528	1529	1530	1531	1532	1533	1534	1535	1536	1537	1538	1539	1540	1541	1542	1543	1544	1545	1546	1547	1548	1549	1550	1551	1552	1553	1554	1555	1556	1557	1558	1559	1560	1561	1562	1563	1564	1565	1566	1567	1568	1569	1570	1571	1572	1573	1574	1575	1576	1577	1578	1579	1580	1581	1582	1583	1584	1585	1586	1587	1588	1589	1590	1591	1592	1593	1594	1595	1596	1597	1598	1599	1600	1601	1602	1603	1604	1605	1606	1607	1608	1609	1610	1611	1612	1613	1614	1615	1616	1617	1618	1619	1620	1621	1622	1623	1624	1625	1626	1627	1628	1629	1630	1631	1632	1633	1634	1635	1636	1637	1638	1639	1640	1641	1642	1643	1644	1645	1646	1647	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659	1660	1661	1662	1663	1664	1665	1666	1667	1668	1669	1670	1671	1672	1673	1674	1675	1676	1677	1678	1679	1680	1681	1682	1683	1684	1685	1686	1687	1688	1689	1690	1691	1692	1693	1694	1695	1696	1697	1698	1699	1700	1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711	1712	1713	1714	1715	1716	1717	1718	1719	1720	1721	1722	1723	1724	1725	1726	1727	1728	1729	1730	1731	1732	1733	1734	1735	1736	1737	1738	1739	1740	1741	1742	1743	1744	1745	1746	1747	1748	1749	1750	1751	1752	1753	1754	1755	1756	1757	1758	1759	1760	1761	1762	1763	1764	1765	1766	1767	1768	1769	1770	1771	1772	1773	1774	1775	1776	1777	1778	1779	1780	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791	1792	1793	1794	1795	1796	1797	1798	1799	1800	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822	1823	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	244
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	-----

$$J=7,3$$

Fig. A-6. Elevation View of Temperature Distribution [$^{\circ}\text{F}$]
Calculated by COMMIX for QSS at 1 Day Without Overflow

$$J=8$$

Fig. A-7. Temperature Distribution [°F] Calculated by COMMIX
in RVL/RV Gap for QSS at 1 Day Without Overflow

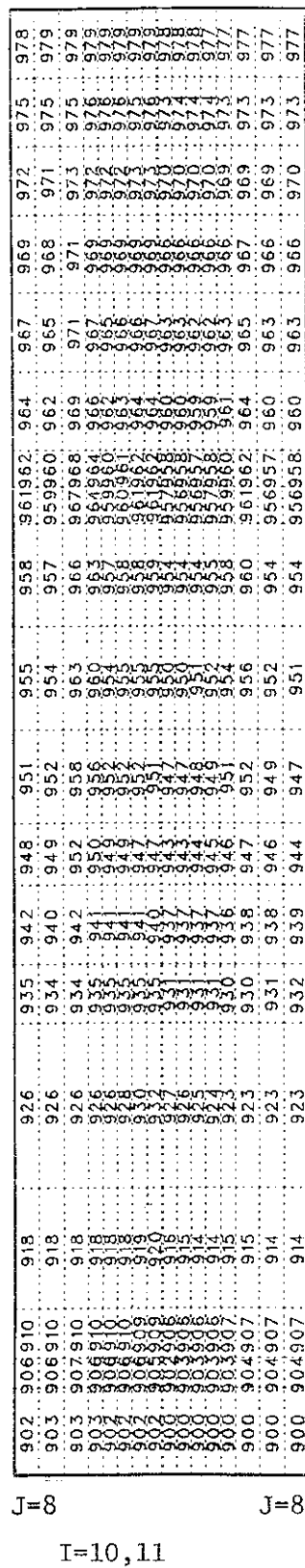


Fig. A-8. Temperature Distribution [°F] Calculated by COMMIX in RV/GV Gap for QSS at 1 Day Without Overflow

J-8
$$l = 12, 13$$

Fig. A-9. Temperature Distribution [°F] Calculated by COMMIX
in GV/CC Gap for QSS at 1 Day Without Overflow

$$J = 7$$

Fig. A-10. Representative Radial Temperature Distribution [°F] Calculated by COMMIX at Top of Hot Pool for QSS at 1 Day Without Overflow

109	112	117	125	146	152	160	166	175	186	197	201	205	213	221	230	237	244	251
111	114	120	135	156	163	172	180	191	203	215	219	224	233	242	251	259	267	275
1075	109	1086	1068	1095	1104	1110	1114	1117	1122	1130	1132	1136	1147	1155	1161	1167	1168	1168
1076	099	1084	1085	1088	1095	1111	1112	1117	1122	1130	1132	1136	1147	1155	1161	1167	1168	1168
1076	099	1084	1084	1089	1095	1111	1112	1118	1122	1130	1132	1136	1147	1155	1161	1167	1168	1168
1077	098	1097	1091	1118	1124	1133	1173	1171	1170	1169	1169	1169	1168	1169	1169	1168	1168	1169
1077	098	1098	1096	1130	1160	1163	1175	1167	1162	1169	1169	1169	1168	1169	1169	1168	1168	1169
1077	098	1098	1097	1158	1158	1169	1175	1168	1168	1168	1168	1168	1168	1168	1168	1168	1168	1169
1077	097	1097	1097	1180	1178	1177	1177	1172	1169	1169	1169	1169	1168	1168	1168	1168	1168	1169
1078	097	1097	1097	1180	1178	1175	1175	1170	1169	1169	1169	1169	1168	1169	1169	1168	1168	1169
1078	097	1097	1096	1168	1168	1167	1171	1167	1168	1169	1169	1169	1168	1168	1168	1168	1168	1169
1078	096	1097	1095	1158	1160	1165	1165	1167	1166	1169	1169	1169	1168	1168	1168	1168	1168	1169
1077	098	1097	1091	1119	1123	1126	1164	1167	1167	1167	1167	1167	1167	1168	1168	1168	1168	1168
1078	094	1081	1084	1091	1092	1095	1109	1112	1112	1113	1101	1105	1101	1105	1101	1105	1101	1105
1077	095	1082	1085	1089	1082	1095	1095	1096	1096	1096	1096	1096	1096	1096	1096	1096	1096	1096
1076	100	1085	1086	1095	1103	1101	1110	1111	1113	1114	1096	1112	1116	1154	1158	1167	1168	1168
1075	100	1085	1088	1094	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102
111	114	120	125	156	163	172	180	191	203	215	219	224	233	242	251	259	267	275
109	112	117	125	146	152	160	166	175	186	197	201	205	213	221	230	237	244	251

J=7,3

Fig. A-13. Elevation View of Temperature Distribution [$^{\circ}\text{F}$]
 Calculated by COMMIX for QSS at 1 Day With Overflow

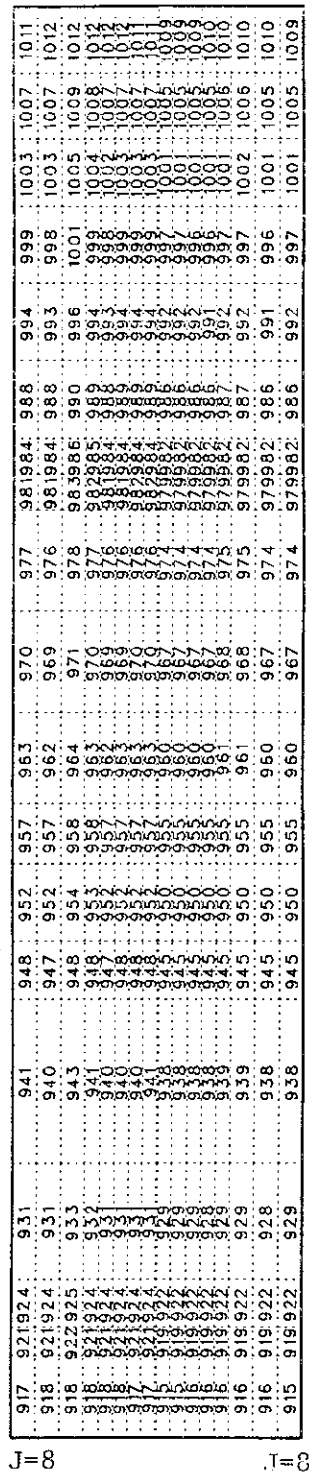
1119	1126	1134	1142	1144	1147	1152	1157	1161	1164	1167	K=19
1119	1126	1134	1142	1144	1147	1152	1156	1161	1164	1167	
1120	1126	1134	1142	1144	1147	1152	1156	1161	1164	1167	
1120	1125	1131	1138	1142	1147	1152	1156	1161	1164	1167	
1120	1125	1131	1137	1142	1147	1152	1157	1161	1164	1167	
1120	1125	1131	1137	1142	1148	1153	1157	1161	1164	1167	
1120	1125	1131	1137	1142	1148	1152	1157	1161	1164	1167	
1120	1125	1131	1137	1142	1147	1152	1156	1161	1164	1168	
1118	1123	1130	1138	1141	1144	1148	1153	1157	1161	1164	
1118	1123	1130	1138	1142	1145	1149	1153	1157	1160	1163	
1118	1123	1130	1138	1142	1145	1149	1153	1157	1159	1162	
1118	1123	1130	1138	1142	1145	1149	1153	1157	1160	1163	
1118	1123	1130	1138	1141	1144	1148	1153	1157	1161	1164	
1117	1124	1132	1139	1142	1144	1148	1153	1157	1160	1164	
1117	1124	1132	1139	1142	1144	1148	1153	1157	1160	1164	
1117	1124	1132	1139	1142	1144	1149	1153	1157	1160	1163	

J=8

J=9

I = 8, 9

Fig. A-14. Temperature Distribution [$^{\circ}$ F] Calculated by COMMIX in RVL/RV Gap for QSS at 1 Day With Overflow



I = 10, 11

Fig. A-15. Temperature Distribution [$^{\circ}\text{F}$] Calculated by COMMIX in RV/GV Gap for QSS at 1 Day With Overflow

J=8
$$l = 12, 13$$

Fig. A-16. Temperature Distribution [°F] Calculated by COMIX
in GV/CC Gap for QSS at 1 Day With Overflow

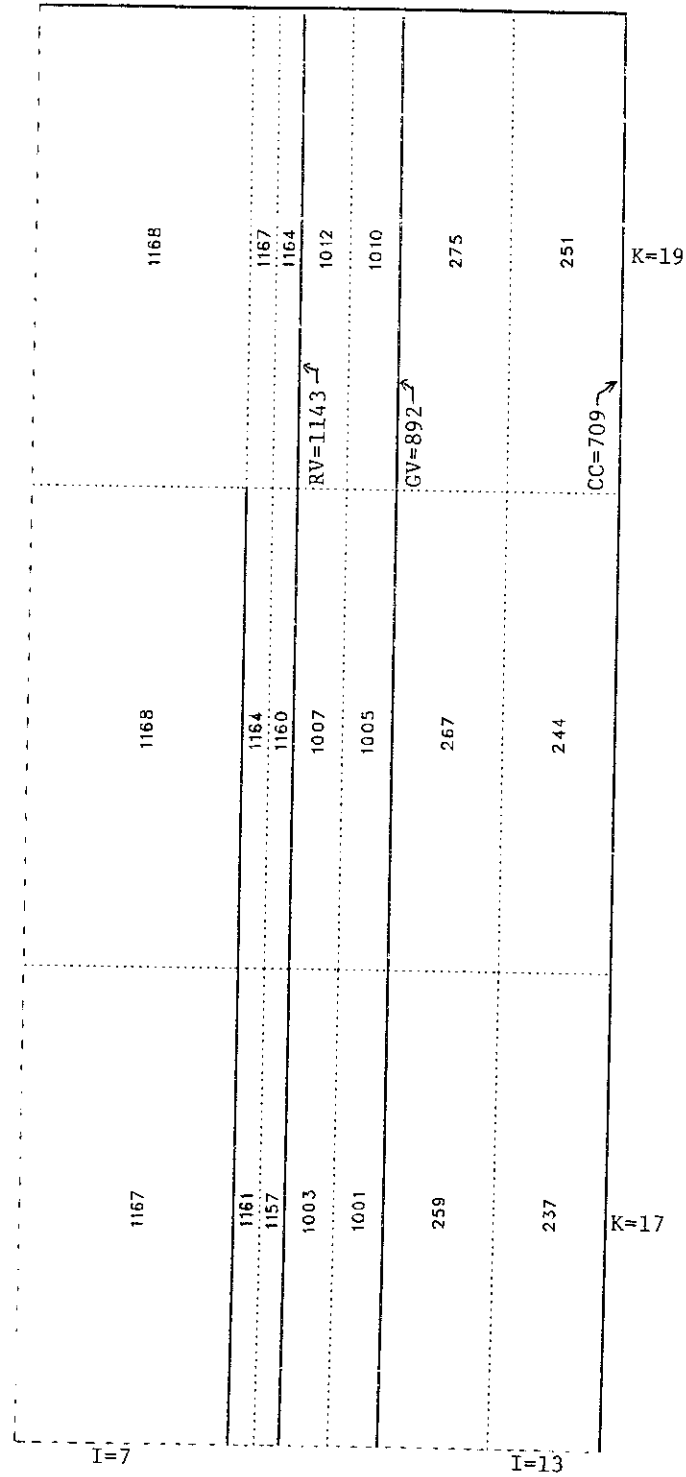


Fig. A-17. Representative Radial Temperature Distribution [°F] Calculated by COMMIX at Top of Hot Pool for QSS at 1 Day With Overflow

